COLUMBIA UNIVERSITY

BIG DATA IN TRANSPORTATION- CIENE4011

Professor Xuan Sharon Di

Report of Elderly Pedestrian Safety at Urban Intersections

Assessing the impact of traffic signal configurations on elderly pedestrian safety and mobility at the Amsterdam and 106th Street intersection, highlighting the potential for tailored infrastructure improvements.

Benett Jonathan, David Vivish, Julia Moncayo von Hase, Nathan Tuil, Shengwei Dai, Yuka Sogawa

Abstract

The primary goal of this field experiment was to assess how traffic signals at intersections influence the safety and mobility of older pedestrians. More specifically the intersection between Amsterdam and 106th Street. With a focus on this demographic, we aimed to identify critical areas where intersection safety can be improved through better traffic signal management and infrastructure modifications. Our methodology involved a combination of quantitative data collection through traffic counts and qualitative data collection via surveys targeted at older pedestrians. Traffic counts were conducted at the mentioned intersection during peak hours to understand traffic flow dynamics, while surveys were distributed to older pedestrians to gather insights on their experiences and safety perceptions at this intersections.

1 Problem Statement

1.1 Objective

The purpose of this study is to evaluate the impact of traffic signal operations on the safety and mobility of older pedestrians at urban intersections. This demographic often faces unique challenges that can significantly impair their ability to navigate city streets safely [2].

1.2 Introduction to Pedestrian Safety

Pedestrian safety is an important public health issue, especially in urban areas, such as New York City, where intersections are congested and the interaction between pedestrians and vehicles is frequent. While all pedestrians are at some risk, older adults face heightened dangers due to physiological, sensory, and cognitive changes associated with aging [2].

1.3 Challenges Faced by Older Pedestrians

Older pedestrians normally move with slower walking speeds and require more time to cross streets. They may also have impaired vision or hearing, making it difficult to respond to conventional traffic cues. Also, their increased vulnerability to serious injuries in the event of an accident makes understanding and improving their interaction with traffic systems of great importance. These challenges include:

- Older pedestrians may not be able to cross intersections within the time allocated by standard traffic signals [4].
- Reduced hearing and vision complicate their ability to navigate safely, especially where auditory or visual signals are not adequately tailored to their needs [3].
- The physical frailty of older adults means that accidents at intersections are more likely to result in severe injuries or fatalities for this group [1].

1.4 Significance of Optimizing Traffic Signals

Optimizing traffic signals to accommodate the needs of older pedestrians is not just about improving their safety and mobility; it's also about enhancing the overall inclusivity and accessibility of urban environments. Effective traffic signal management can:

- Reduce the incidence of pedestrian-related accidents.
- Encourage more older adults to engage in healthy, active transportation.
- Increase the overall quality of life by promoting safer community environments.

1.5 Approach

This study begins with a broad examination of pedestrian safety issues and then narrows down to focus specifically on older pedestrians. We will investigate how current traffic signal configurations at various intersections either support or hinder their mobility and safety, and propose targeted adjustments aimed at creating more age-friendly urban spaces.

2 Data Description

2.1 Quantitative Traffic Counts

2.1.1 Methodology

On April 24th, between 4:00 and 5:00 PM, a comprehensive observational study was conducted at the intersection of 106th Street and Amsterdam Avenue. The aim was to capture a detailed depiction of traffic behavior and pedestrian activity within this urban setting. The study employed video recording from two distinct points to ensure comprehensive coverage of the entire intersection.

During the initial hour-long period from 4:00 to 5:00 PM, video footage was systematically collected to document the dynamic interactions among vehicles, cyclists (including ebikes and scooters), and pedestrians. This footage served as the basis for later analysis of traffic patterns and pedestrian behaviors. Special attention was given to capturing activity in all eight available directions: North-East, North-west, North-South, West-South, West-East, East-North, East-South, and East-West.

To ensure a comprehensive understanding of traffic volume and pedestrian activity, data collection occurred at five-minute intervals throughout the study period. This approach facilitated the accurate recording of the number of vehicles, cyclists, pedestrians, and specifically, older pedestrians traversing the intersection.

2.1.2 Traffic Volume and Pedestrian Activity Data

Overall, the data shows a clear pattern of traffic flow with vehicles dominating the roads, particularly in the North-South direction in Table 1. Pedestrian activity is also significant in certain directions, while cyclists, including those on ebikes and scooters, contribute minimally to the traffic in 4:00 to 5:00 PM in Table 2. For vehicles, the data indicates a pronounced movement predominantly in the North-South direction, which consistently registers the highest counts throughout the hour. There is also considerable traffic in the East-West and West-East directions, though these numbers are significantly lower than those in the North-South direction. Other directions, such as North-East and North-West, along with minor routes like East-North and East-South, show relatively sparse vehicle traffic. In comparison, cyclist traffic is considerably lower, with no particular direction dominating. The counts across all directions and intervals remain low, with slight peaks in the West-East and East-West directions. Pedestrian data mirrors the vehicle trends to some extent, with the highest foot traffic also in the North-South and East-West directions. Overall pedestrian counts exceed those of cyclists but are lower than vehicle counts. The data also includes a specific count for older pedestrians, who are much fewer in number.

Table for vehicles

		4:00-4:05	4:05-4:10	4:10-4:15	4:15-4:20	4:20-4:25	4:25-4:30	4:30-4:35	4:35-4:40	4:40-4:45	4:45-4:50	4:50-4:55	4:55-5:00
CAMERA 1	NORTH-EAST	1	5	1	2	4	3	1	2	5	1	3	2
	NORTH-WEST	8	7	5	6	7	5	9	8	6	7	5	7
	NORTH-SOUTH	37	34	36	35	33	38	34	32	37	35	36	33
	WEST-SOUTH	2	1	2	3	1	2	4	2	3	1	2	3
	WEST-NORTH												
	WEST-EAST	12	8	14	10	15	9	11	13	7	12	10	14
CAMERA 2	EAST-NORTH	4	4	5	4	5	4	8	2	4	5	7	4
	EAST-SOUTH	7	5	2	6	2	4	5	4	8	5	2	4
	EAST-WEST	15	11	14	9	15	5	14	12	15	12	4	13
	SOUTH-EAST												
	SOUTH-WEST												
	SOUTH-NORTH												

Table for cyclists (cyclists includes bike, ebike, and scooter)

		4:00-4:05	4:05-4:10	4:10-4:15	4:15-4:20	4:20-4:25	4:25-4:30	4:30-4:35	4:35-4:40	4:40-4:45	4:45-4:50	4:50-4:55	4:55-5:00
CAMERA 1	NORTH-EAST	1	0	2	1	2	0	1	0	2	1	2	0
	NORTH-WEST	1	0	2	0	1	0	1	1	2	0	1	0
	NORTH-SOUTH	1	1	1	1	1	0	1	0	1	1	1	0
	WEST-SOUTH	1	1	1	2	1	0	0	2	1	1	1	1
	WEST-NORTH												
	WEST-EAST	1	3	0	3	2	0	2	2	0	3	2	0
CAMERA 2	EAST-NORTH	0	1	0	0	1	1	0	2	0	0	1	0
	EAST-SOUTH	1	1	0	1	0	2	0	0	1	0	1	0
	EAST-WEST	2	0	1	0	1	0	0	1	2	0	1	1
	SOUTH-EAST												
	SOUTH-WEST												
	SOUTH-NORTH												

Figure 1: Traffic Volume of Vehicles and Cyclists

Table for pedestrians (Total)

		4:00-4:05	4:05-4:10	4:10-4:15	4:15-4:20	4:20-4:25	4:25-4:30	4:30-4:35	4:35-4:40	4:40-4:45	4:45-4:50	4:50-4:55	4:55-5:00
CAMERA 1	NORTH-EAST	3	4	2	2	4	1	0	3	4	6	2	2
	NORTH-WEST	1	5	3	4	2	4	6	5	4	2	3	4
	NORTH-SOUTH	14	24	22	19	17	24	21	27	34	18	26	27
	WEST-SOUTH	6	4	2	3	1	4	2	6	7	5	4	5
	WEST-NORTH												
	WEST-EAST	4	7	12	7	3	9	6	10	14	6	7	6
CAMERA 2	EAST-NORTH	2	4	6	5	6	8	4	6	8	7	6	8
	EAST-SOUTH	5	4	6	8	2	4	8	9	7	3	4	7
	EAST-WEST	9	4	8	9	7	8	5	8	4	5	6	8
	SOUTH-EAST												
	SOUTH-WEST												
	SOUTH-NORTH												

Table for pedestrians (Older)

		4:00-4:05	4:05-4:10	4:10-4:15	4:15-4:20	4:20-4:25	4:25-4:30	4:30-4:35	4:35-4:40	4:40-4:45	4:45-4:50	4:50-4:55	4:55-5:00
CAMERA 1	NORTH-EAST	0	0	0	0	1	0	0	3	0	0	1	0
	NORTH-WEST	0	0	0	2	0	2	0	0	0	2	0	0
	NORTH-SOUTH	1	2	0	0	1	0	0	0	0	2	0	3
	WEST-SOUTH	0	0	0	0	0	1	0	0	2	0	0	0
	WEST-NORTH												
	WEST-EAST	0	0	0	0	0	0	1	0	0	0	1	0
CAMERA 2	EAST-NORTH	0	0	0	0	1	0	0	1	0	0	0	2
	EAST-SOUTH	0	0	1	0	0	0	1	0	0	1	0	0
	EAST-WEST	1	0	0	0	1	0	0	2	0	0	2	2
	SOUTH-EAST												
	SOUTH-WEST												
	SOUTH-NORTH												

Figure 2: Pedestrian Activity of all-age and Olders (Age 65+)

2.2 Qualitative Survey Interview

2.2.1 Data Collection Approach

Following the observational phase, from 5:00 to 6:00 PM, structured interviews were conducted with older pedestrians. A questionnaire comprising ten carefully crafted questions with one hypothesis was utilized to explore various facets of the older pedestrians' experiences at the intersection (Table 3). The questionnaire covered topics such as the influence of traffic signals and interactions with moving vehicles. The hypothesis was that older pedestrians experience higher levels of safety and mobility at intersections equipped with pedestrian-specific signals and auditory cues compared to intersections with standard traffic signals.

2.2.2 Survey Content

The survey aimed to understand the influence of traffic signals at intersections on the safety and mobility of older pedestrians (Table 3). The primary question seeks to explore how different types of traffic signals affect older pedestrians' perceptions of safety and mobility. The accompanying questions delve into specific aspects of their experiences, such as the frequency of their walks in urban areas, their feelings of safety at intersections, their ability to understand and follow traffic signals, and the adequacy of the crossing time provided. Additional questions address the clarity of pedestrian signals, the usefulness of auditory cues, experiences with advanced intersection features like countdown timers or tactile paving, and any incidents or near-misses at intersections. The hypothesis posited alongside these questions suggests that older pedestrians experience heightened levels of safety and mobility at intersections equipped with pedestrian-specific signals and auditory cues compared to those with standard traffic signals. This implies an assumption that tailored traffic management features could significantly enhance the pedestrian experience for the elderly, potentially reducing accidents and improving their confidence and independence while navigating city streets.

Group members	Bennett Jonathan, David Vivish, Julia Moncayo von Hase, Nathan Tuil, Shengwei Dai, Yuka Sogawa	
	Questions	Hypothesis
Big Question	How do traffic signals at intersections influence the safety and mobility of older pedestrians?	1. Older pedestrians experience higher levels of safety and mobility at intersections equipped with pedestrian-specific signals and auditory cues compared to intersections with standard traffic signals.
Other Questions	1. Demographic Information: a. How old are you? [check if 65+] b. Do you have any mobility impairments? (Yes/ No) 2. How often do you walk in urban areas? (Daily, several times a week, weekly, rarely) 3. On a scale of 1- 5, how safe do you generally feel crossing intersections? 4. Do you find standard traffic signals easy to understand and follow? (Y/ No) 5. Do you feel that you have enough time to cross the street at intersections? (Yes/ No)	6. Are the pedestrian signals at intersections clear and easy to see? (Yes/ No) 7. Are auditory cues helpful to you at an intersection? Would you prefer more intersections to have auditory signals? (Yes/ No) 8. Have you used intersections with pedestrian countdown timers or tactile paving? If yes, what was your experience? (open- ended) 9. Have you ever experienced a near-miss or an accident at an intersection? If yes, can you describe what happened? (open- ended) 10. What changes at intersections would make you feel safer and more confident as a pedestrian? (open- ended)

Figure 3: Questionnaire

2.2.3 Demographic Makeup

The survey was conducted among 19 individuals aged 65 and older, with a focus on their mobility impairments, experiences, and perceptions concerning pedestrian safety in urban environments. The group predominantly consists of older adults, with 15 out of the 19 participants reporting some form of mobility impairment such as issues with knees, hips, or requiring the use of a wheelchair. This demographic tends to engage in daily or several times a week walking routines despite their physical limitations (Table 4). The survey reveals a consensus among the participants regarding the adequacy of time allotted to cross at intersections, with most finding pedestrian signals easy to see and auditory signals helpful. There's a notable interest in further enhancements to pedestrian infrastructure, like better auditory cues and more visible signals, suggesting a need for more tailored urban planning to accommodate aging populations with mobility challenges. Several participants also mentioned experiences with near-miss or actual accidents at intersections, emphasizing the need for improved safety measures and possibly changes in traffic rules to enhance the confidence and security of older pedestrians in urban settings.

Big Question: How do traffic signals at intersections influence the safety and mobility of older pedestrians?

	Age (65+)	Mobility Impairm	If specified..	How often do yo	On a scale of 1-	Do you find stan	Do you feel that	Are the pedestri	Are auditory cue	Would you prefer	Have you used i	Experience	Have you ever e	What changes at intersections would make you feel sa
Person 1	75	Yes	knee	Daily	5	Yes	Yes	Yes	Yes	Yes	Yes	very good, preve	No	standarize more across the entire city
Person 2	67	No		Daily	5	Yes	Yes	Yes	Yes	Yes	Yes	good	No	
Person 3	72	Yes	knee	Sever...	3	No	No	Yes	Yes	Yes	Yes	good	No	have a person walk them at intersections
Person 4	82	Yes	wheelchair	Weekly	3	Yes	No	Yes	Yes	Yes	Yes	good	No	more auditory
Person 5	66	No		Sever...	4	Yes	Yes	Yes	Yes	No	Yes	indifferent	No	more time to cross
Person 6	70	Yes	knee	Daily	4	Yes	Yes	Yes	Yes	Yes	Yes	very helpful	No	more time to cross
Person 7	68	No		Sever...	4	Yes	Yes	Yes	Yes	Yes	Yes	very good	No	doesnt know, they dont follow traffic rules
Person 8	87	No		Sever...	4	Yes	Yes	Yes	Yes	Yes	Yes	very good	No	more pedestrian islands
Person 9	70	Yes	knee	Daily	5	Yes	No	Yes	Yes	Yes	Yes	good	No	
Person 10	72	Yes	hip problems	Sever...	5	Yes	Yes	Yes	Yes	Yes	Yes	very good	No	button to cross doesnt seem to work
Person 11	65	Yes	knee	Sever...	4	Yes	Yes	Yes	Yes	Yes	Yes	helpful	No	doesnt follow traffic rules
Person 12	87	Yes	wheelchair	Rarely	2	Yes	No	No	Yes	Yes	Yes	helpful	No	
Person 13	67	No		Daily	4	Yes	Yes	Yes	No	No	Yes	makes them feel	No	spoken messages are better than beep sounds
Person 14	72	No		Daily	5	Yes	No	No	Yes	Yes	Yes	prevents slipping	No	auditory signal should be louder
Person 15	71	Yes	didnt want to sha	Sever...	4	Yes	Yes	Yes	Yes	Yes	Yes	good	No	
Person 16	63	Yes	knee	Weekly	4	Yes	No	Yes	Yes	Yes	No	good	Yes	more time to cross
Person 17	65	Yes	knee	Weekly	5	Yes	Yes	Yes	Yes	Yes	Yes	indifferent	No	police presence
Person 18	69	Yes	didnt want to sha	Daily	5	Yes	Yes	Yes	Yes	Yes	Yes	good good	No	
Person 19	75	Yes	hip	Rarely	5	Yes	No	Yes	Yes	Yes	Yes	helpful	No	more time to cross

Figure 4: Questionnaire Survey Result

3 Data Visualization & Interpretation

3.1 Traffic Volume Analysis

3.1.1 Hourly Traffic Flow

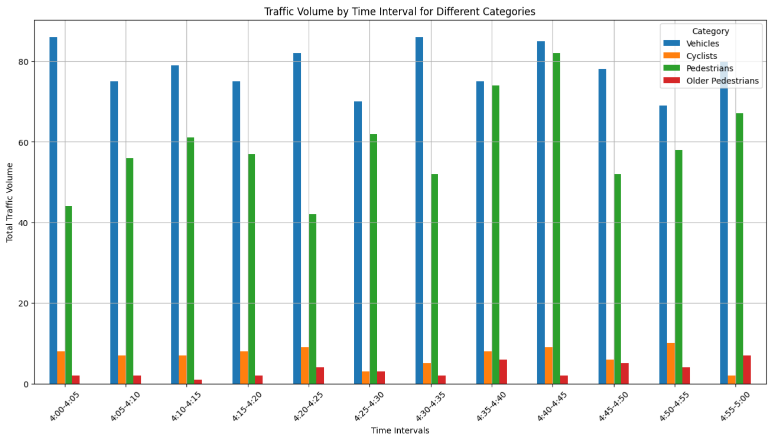

Figure 5: Traffic Volume by Time Interval for Different Categories

Figure 5 represents traffic volumes in four categories: vehicles (blue), cyclists (orange), pedestrians (green), and older pedestrians (red), over a series of time intervals between 4pm and 5pm at the intersection Amsterdam and 106th Street. We observe that vehicles are by far the dominant category across all time intervals, which highlights the heavy vehicle usage of the intersection. This is very important for understanding the risk exposure to non-vehicular traffic, particularly older pedestrians who may have slower crossing speeds and higher vulnerability. Cyclist traffic is significantly lower than vehicle traffic but consistent across time intervals. This consistency suggests a stable flow of cyclists that need to be considered in traffic signal timing and infrastructure design to ensure safe interactions with both vehicles and pedestrians. General pedestrian traffic is higher than cyclist traffic but still much lower than vehicle traffic. The relatively higher volume compared to cyclists underscores the need for pedestrian-focused traffic management strategies. Older pedestrian traffic, while the lowest in volume, shows notable peaks and troughs. The presence of older pedestrians, even in smaller numbers, is important because they are a vulnerable demographic. Their movement patterns should influence the design of traffic control measures such as longer crossing times, better signal visibility, and perhaps even the addition of resting points at larger intersections.
There are certain times, such as between 4:00-4:05, 4:25-4:30, and 4:40-4:45, where overall traffic volume peaks. These are critical times where the risk of accidents could be higher due to the increased volume of mixed traffic. Traffic management strategies might need to focus on these intervals to enhance safety, such as by adjusting signal timings to longer pedestrian phases or implementing all-red intervals to clear the intersection. During lower traffic volumes, like between 4:10-4:15 and 4:50-4:55, it might be safer for older pedestrians to cross. However, even during these times, careful consideration is needed to maintain safety, as the relative increase in pedestrian to vehicle ratio could lead to potential risks if drivers are less attentive due to lower overall traffic density.

3.1.2 Directional Traffic Volume Comparison

Directions oriented north and south may serve as major commuter routes, resulting in higher traffic volumes during peak commuting hours. These directions may require interventions such as optimized signal timings and pedestrian refuge islands to enhance safety for older pedestrians crossing busy roads. Directions oriented east and west may intersect with residential or commercial areas, resulting in variable traffic patterns influenced by local activities or others. Signal coordination and pedestrian infrastructure improvements can help address safety concerns for older pedestrians navigating these intersections.

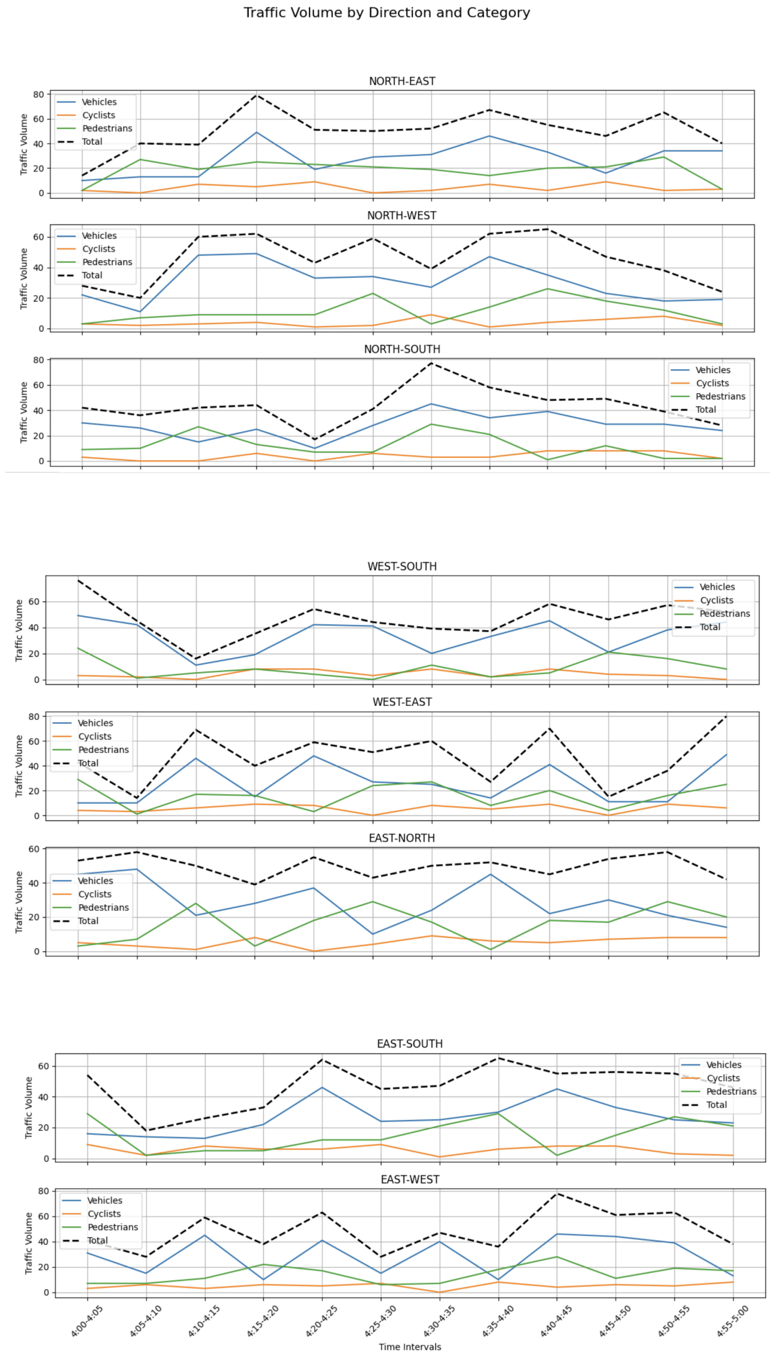

Figure 6: Traffic Volume by Direction and Category

In Figure 6 the dashed lines represent the total traffic volume, which includes all categories. Peaks in total traffic volume could indicate higher risk times for all pedestrians, including older adults, due to the increased complexity and reduced reaction times at these busy periods.

Each direction shows different traffic volume patterns. For instance, some directions may show a smoother traffic pattern, while others have more pronounced peaks. This variability could suggest different levels of signal timing optimization across directions. Notably, directions like NORTH-SOUTH and EAST-WEST exhibit significant fluctuation, suggesting these could be major thoroughfares or suffer from specific traffic signal timing issues that could affect pedestrian crossing phases.

3.2 Pedestrians and Safety Concerns

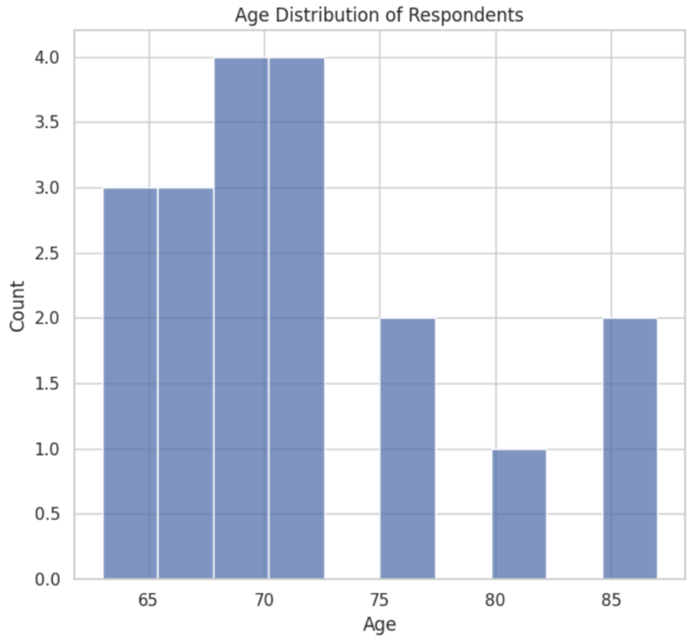

Figure 7: Age Distribution of Respondents

The histogram displaying the Age Distribution of Respondents in Figure 7 reveals a broad age range with peaks at the lower end (around age 65) and another noticeable group in the early 80s. This distribution is significant as it shows a diversity of ages among the older pedestrians, which urban planners must consider. Luckily we got a wide range of ages such that the analysis of our findings can be implemented for a major portion of citizens.

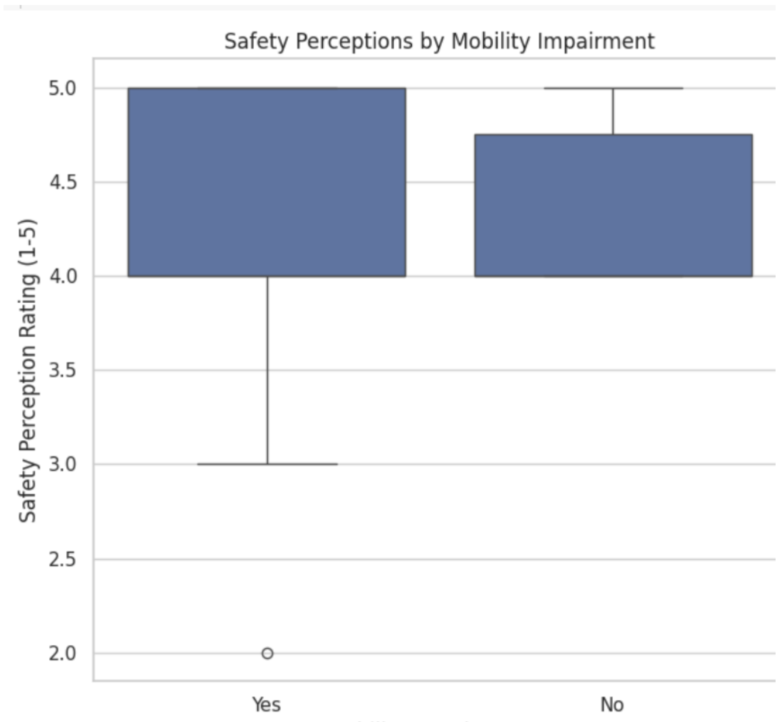

Figure 8: Safety Perception by Mobility Impairment

The Safety Perceptions by Mobility Impairment box plot in Figure 8 provides a comparison of safety perception ratings between those with mobility impairments and those without. Notably, the median safety perception is slightly higher among those without impairments, but the range of responses, especially the lower quartile in the mobility-impaired group, suggests that individuals in this group can feel significantly less safe. This finding underscores the need for tailored urban design that addresses the specific safety concerns and requirements of pedestrians with mobility impairments.

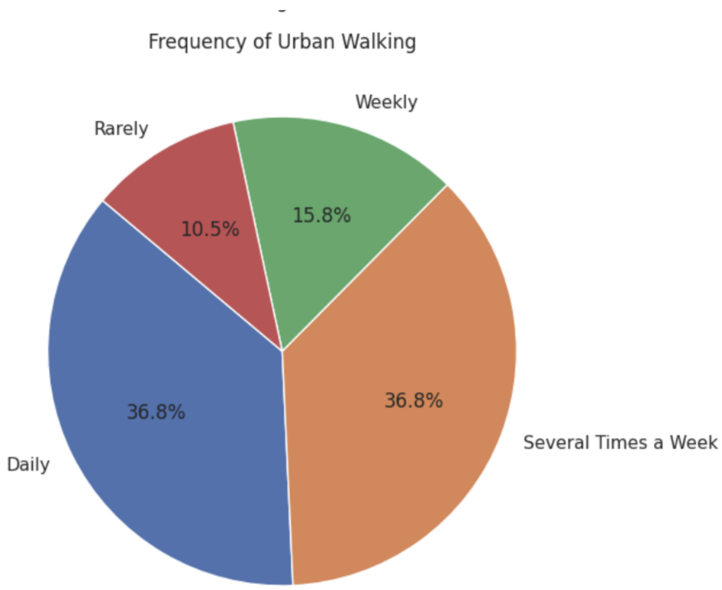

Figure 9: Frequency of Urban Walking

The Frequency of Urban Walking pie chart in Figure 9 illustrates the regularity with which older adults walk in urban settings, with a significant proportion doing so daily. This emphasizes the importance of safe urban environments as these are not occasional spaces for older adults but are integral to their daily routines. Urban design that promotes ease of mobility and minimizes hazards is crucial in fostering an age-friendly city that encourages older adults to maintain their independence and physical health through regular walking.

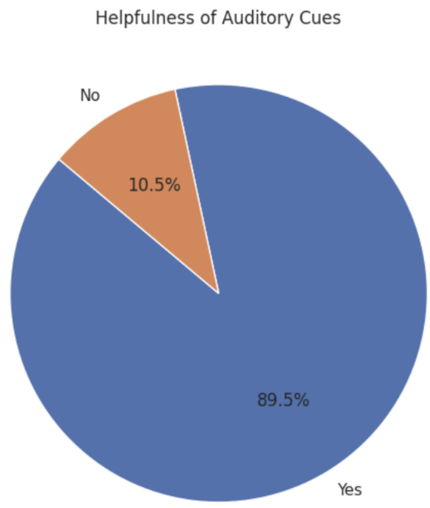

Figure 10: Helpfulness of Auditory Cues

The Helpfulness of Auditory Cues pie chart in Figure 10 indicates a strong preference for auditory signals, with 89.5% of respondents finding them helpful. This overwhelming majority highlights the importance of auditory cues in traffic signals at intersections, aiding those with visual impairments or those who benefit from dual sensory input to navigate streets safely.

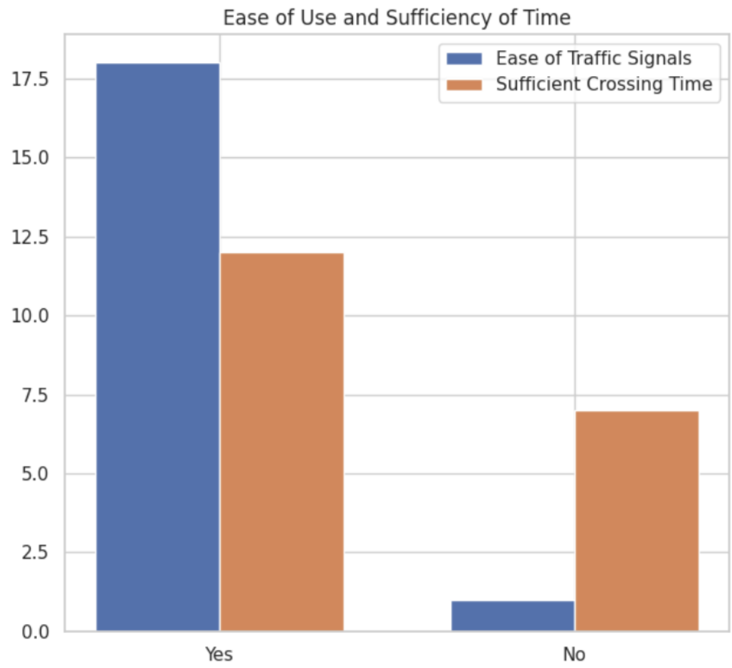

Figure 11: Ease of Used and Sufficiency of Time

The bar chart on Ease of Use and Sufficiency of Time in Figure 11 examines respondents' views on the ease of using traffic signals and whether the crossing times are sufficient. Most respondents find traffic signals easy to use, but a significant number report insufficient crossing time. This discrepancy points to a critical area of concern: while the technology may be user-friendly, its settings, like the allotted time for crossing, may not adequately accommodate the slower walking speeds of some older adults.

The collection of visualizations from the survey data on older pedestrians at urban intersections provides comprehensive insights that are important for guiding urban planning and policy enhancements aimed at increasing pedestrian, especially older pedestrian, safety and accessibility. Analyzing the data reveals a nuanced understanding of how age, mobility impairments, and urban design interplay to affect the daily lives of older adults navigating city environments. Starting with the Safety Perceptions by Mobility Impairment plot, we see a clear disparity in safety perceptions between those with and without mobility impairments. Those without impairments generally report feeling safer, possibly reflecting an urban environment that better caters to their mobility needs compared to those with impairments. This discrepancy suggests that current urban designs might lack comprehensive inclusivity, highlighting the urgent need for improvements such as well-maintained sidewalks, more accessible pedestrian signals, and clearer pathways that can accommodate mobility aids like wheelchairs and walkers. The Frequency of Urban Walking data indicates that a substantial portion of older adults engage in walking frequently, with many walking daily. This high level of activity accentuates the importance of pedestrian-friendly urban design. Since older adults are active users of public spaces, it is crucial that these areas are designed to ensure their safety and comfort, suggesting a demand for continuous pedestrian paths, ample resting areas, and safe crossing zones, especially at busy intersections. Moreover, the overwhelming majority of respondents in the Helpfulness of Auditory Cues data find auditory cues beneficial, indicating that such features are essential for safe navigation at intersections. This is particularly crucial for those with visual impairments or who may be more easily disoriented. Incorporating auditory signals at more intersections could markedly improve the autonomy and safety of older pedestrians, fostering an environment that supports their mobility needs. However, the analysis of Ease of Use and Sufficiency of Time reveals that while traffic signals are generally easy to use, the crossing times often do not meet the needs of older adults, many of whom feel that the time allowed is insufficient. This issue can be particularly problematic for those with slower walking speeds or mobility impairments. Addressing this concern requires a reevaluation of signal timings at intersections to accommodate the slower pace of many older adults, ensuring they can cross safely without feeling rushed or endangered. Lastly, the Safety Perception Ratings indicate generally high levels of perceived safety among older pedestrians, an encouraging sign. Nonetheless, the variability in responses, particularly the lower ratings from those with mobility impairments, suggests there are still significant areas for improvement. Enhancing the specific features that these individuals find lacking could help elevate overall perceptions of safety. Integrating these findings, it becomes clear that a holistic approach to urban planning is necessary—one that weaves the needs of older adults into every facet of urban design. From adjusting crossing times and increasing the prevalence of auditory cues to ensuring pedestrian pathways are wide, well-maintained, and free of obstacles, the ultimate goal should be to create inclusive environments that accommodate the needs of all citizens. Such improvements not only enhance the quality of life for older adults but also promote a broader culture of inclusivity and accessibility in urban settings, fostering environments where all individuals can thrive.

The survey responses concerning what changes at intersections would make pedestrians feel safer and more confident highlight several critical insights into pedestrian needs and concerns. A prominent theme across the responses is the desire for more time to cross, which appears multiple times and signifies a general need for longer crossing intervals to accommodate slower walking speeds, possibly influenced by age or mobility issues. Additionally, respondents advocate for better auditory signals, with suggestions for louder signals and a preference for spoken messages over beeps, indicating a need for clearer and more accessible auditory cues at intersections.

Other notable suggestions include standardizing intersection designs and signals across the city to reduce confusion and improve familiarity with pedestrian infrastructure. Some respondents also mention the ineffectiveness of existing push-to-cross buttons and a general perception that drivers do not follow traffic rules, which could be addressed by enhancing the responsiveness of pedestrian signals and increasing police presence to enforce traffic laws. The inclusion of more pedestrian islands is also suggested, providing safer refuges for pedestrians crossing wider streets.

These insights collectively show a demand for more pedestrian-centered designs and robust safety measures at intersections. They reflect a broader community interest in creating urban environments that prioritize pedestrian comfort and safety, accommodating a diverse range of pedestrian abilities and enhancing overall accessibility in urban settings.

3.3 Advanced Visualizations of Correlation for Deeper Insights

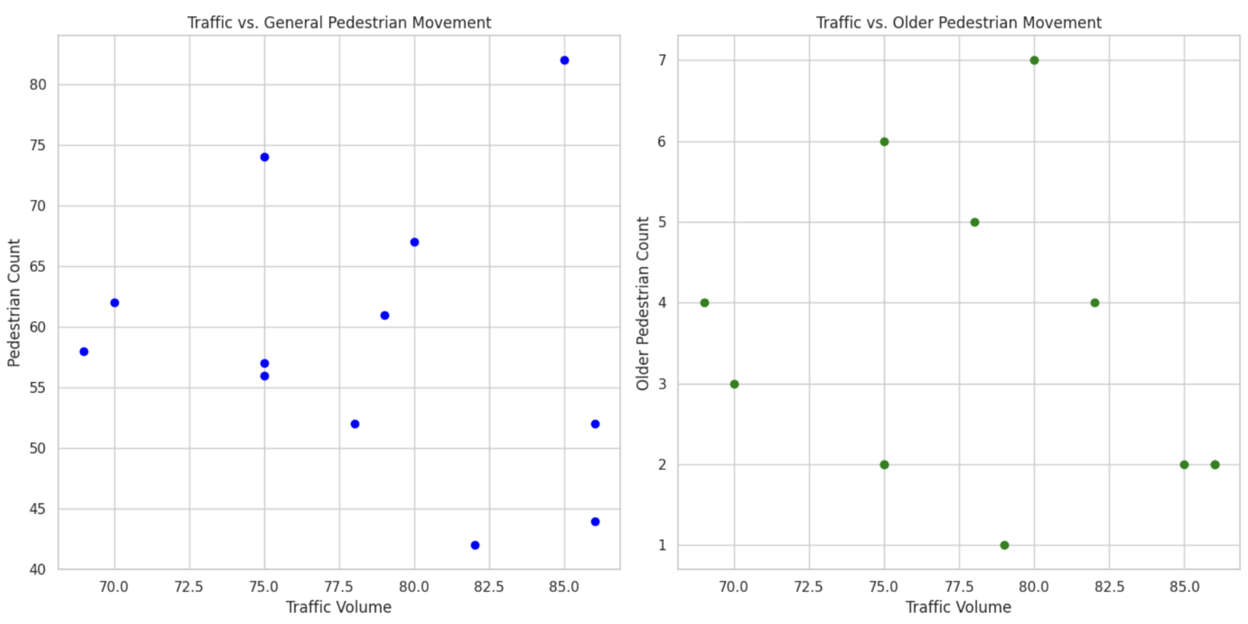

Figure 12: Correlation of Traffic versus Pedestrians

The scatter plots display the relationship between traffic volumes and pedestrian movements for both general and older pedestrians at urban intersections.

The scatter plot in Figure 12 for general pedestrian movement shows a distribution of points that does not immediately suggest a clear or strong correlation between traffic volume and pedestrian counts. Pedestrian counts appear relatively spread out across different traffic volumes, suggesting that pedestrian activity might not be directly impacted by the amount of traffic. This could indicate that pedestrian crossings are sufficiently managed to ensure safety despite varying traffic levels, or it could suggest that pedestrians are accustomed to the traffic patterns and times.

The plot for older pedestrians shows lower counts of pedestrian movement, which is expected given the specific demographic. Similar to the general pedestrian plot, there does not appear to be a direct correlation between traffic volumes and older pedestrian movements. However, the generally lower numbers across all traffic conditions point to the potential need for targeted safety measures. The variability in older pedestrian counts at different traffic volumes could suggest areas where improvements in pedestrian infrastructure (like longer crossing times or better signaling) might enhance safety and accessibility.

The absence of a strong correlation in both plots suggests that while traffic volumes are an important factor, they may not be the predominant influence on pedestrian movements at these intersections. This could indicate that other factors such as time of day, pedestrian signal timings, and urban design may play more significant roles.

4 Policy Making & Validation

This policy proposal is based on the findings and interpretations of the survey and data analysis, confirming the need for further development of urban spaces that prioritize pedestrian safety and accessibility, as well as the necessity for targeted measures at high-risk points. To reduce the risk of accidents and improve the safety and comfortability of pedestrians, policy recommendations are proposed below for urban areas like New York, where on-site surveys were conducted.

- **Expansion of Pedestrian Infrastructure:**
  Increasing the number of pedestrian islands at intersections and improving the safety of risky crosswalks by providing safe refuge points for pedestrians crossing wide roads contribute to creating an environment where even the elderly can walk with the feeling of safe. Additionally, expanding auditory signals, considering the significant reliance on auditory cues by pedestrians, and widening sidewalks are crucial for enhancing the sense of security for pedestrians. Increasing pedestrian-friendly street spaces is expected to alleviate the concerns of all pedestrians about walking in the city.

- **Extension of Crossing Time:**
  Identifying and extending crossing times during peak pedestrian traffic periods, particularly in communities with a high proportion of elderly residents, effectively supports the safe movement of elderly and disabled pedestrians. Moreover, considering extending crossing times in areas with high overall pedestrian traffic, except during peak vehicle traffic hours, can enhance the sense of security in urban walking.
  To validate these effects, it is ideal to continue on-site observations and surveys of passersby as conducted in this survey. However, implementing this on a wide scale across regions may be challenging. On the other hand, a multidimensional and efficient validation of effects is possible through existing frameworks and evolving data analytics.

- **Follow-up Surveys:**
  By collaborating with Community Boards, educational and welfare institutions, and NGOs, conducting periodic questionnaire surveys on streets perceived as dangerous for walking, experienced near-misses, or points where pedestrians feel safe, and providing feedback to the city's transportation authorities, we can conduct regular spot checks to ensure that the above measures are functioning effectively. Especially, by including questions to confirm the improvement of the sense of security in walking for the elderly and disabled, and evaluating the reputation of newly installed pedestrian islands and expanded sidewalks, we can focus on confirming effective maintenance toward achieving an inclusive walking environment.

- **Data Monitoring:**
  If it becomes possible to collect data on pedestrians and vehicles along streets using cameras, as seen in The COSMOS testbed, it will be possible to identify areas where pedestrians and vehicles approach each other or instances where pedestrians continue to cross slowly even when the pedestrian signal turns red. By conducting root cause analyses for detected risks and considering whether risks can be mitigated through improvements in street design or extension of crossing times, effective traffic planning focused on high-need areas can be achieved.

5 Conclusions

An evaluation for the impact of traffic signals towards the safety and mobility of older pedestrians at urban intersections was done by focusing on the intersection between Amsterdam and 106th Street. Both comprehensive quantitative and qualitative data were collected to provide deeper insights into the dynamics of pedestrian traffic, particularly challenges faced by the older population. The study findings show that the importance of optimizing traffic signal management is often underscored and underutilized. They are important to enhance pedestrian safety and promote inclusivity within urban environments.

From a quantitative analysis, it is evident that there is a dominant flow of vehicular traffic with the substantial presence of older pedestrians. This pattern was significant since it occurred on a regular basis. From a qualitative analysis, specifically tailored questions complemented these findings by capturing personal experiences and safety perceptions of older pedestrians, emphasizing a stronger desire for longer crossing times and better auditory cues. Through these analyses, it is imperative that advocating for an urban design that accommodates the unique needs of older pedestrians by enhancing their independence and safety through tailored traffic management strategies is essential to bring a better quality of life for everyone living in the city.

6 Potential Future Work

Future research that can build upon the findings of this study include expanding the study to include multiple intersections across different neighborhoods to provide a more generalized understanding of older pedestrians' needs across varied urban settings. Investigating the role of emerging technologies such as smart traffic management systems and digital twins can also be helpful to improve pedestrian safety and mobility. Another important study that can be implemented is to conduct and assess the long-term effects of these implemented changes over time. This would help better assess the efficacy of different traffic management strategies and infrastructure improvements. A study that focuses on the different design of pedestrian infrastructures such as crosswalks and resting areas to cater a broader range of disabilities and mobility issues among the older population.

7 Each Team Member's Role & Contributions

- **Benett Jonathan:** Did the Conclusion and Potential Future Work sections, and conducted the questionnaire to elderly pedestrians.
- **David Vivish:** Wrote everything in the Markdown in GitHub, and filmed the intersection traffic.
- **Julia Moncayo von Hase:** Did the Data Visualization & Interpretation sections, and conducted the questionnaire to elderly pedestrians.
- **Nathan Tuil:** Did the Introduction section, and conducted the questionnaire to elderly pedestrians.
- **Shengwei Dai:** Did the Data Description section, and filmed the intersection traffic.
- **Yuka Sogawa:** Did the Policy Making & Validation section, and filmed the intersection traffic.

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